Innovative Distributed Power Interconnection and Control Systems

Michele Dybel
Gas Technology Institute, Des Plaines, IL

Randy West
Encorp, Windsor, CO

Presented at the U.S. Department of Energy
Quarterly Distributed Power Program Review Meeting
July 9 – July 10, 2002
Madison, WI

Presentation Overview

- Market-Driven, Technology-Based Solutions
  - Collaborative NREL/DOE program and goals
- Distributed Power Market
  - System applications & customer needs
- Accomplishments and Summary

Development of Innovative Distributed Power Interconnection and Control Systems
Subcontract No. 30605-04
Awarded Under the NREL/DOE Distributed Power Program
Distributed Power System Integration Research and Development
NREL Technical Monitor: Tom Basso
Principal Investigator: Michele Dybel, Gas Technology Institute, Des Plaines, IL
Subtier Principal Investigators: Larry Adams and Randy West, Encorp, Windsor, CO

NREL/DOE Project Objective and Goals

Key enabling technologies and system-level integration to help Distributed Power market participants more *fully capture the total value provided by DP products.*

- Cost-effective DP grid interconnection products, software, and communication solutions
- Improved economics for broad range of DP power systems
- Enhanced DP product capability to integrate, interact, and provide operational benefits

NREL/DOE Advanced Interconnect System: Three Phase Work Plan

- Base Year:
  - Core Technology & Software Development
  - Develop Next Generation GPC Controller
  - Significant Performance Enhancement
- Option Year 1:
  - Application & System Level Command and Control
  - Demonstration
- Option Year 2:
  - Further Development/Demonstration of System Benefits and Validation of Industry Communication Standards

Program Plan/Tasks

	Core Enabling Technology	
Base Year	**(1)**	**Develop Prototype Advanced Controller**
	(2)	**Develop Prototype Power Sensing Board**
	(3)	**Expanded Suite of Communication Capabilities**
	(4)	**Interface for Revenue-Grade Meter**
	(5)	**Demonstrate Interconnect DP Device**
	System Level Command & Control	
Option Year 1	**(6)**	**Type Testing**
	(7)	**System Command and Control**
	(8)	**Demonstration of Controlled DP**
	Interoperability & Communications	
Option Year 2	**(9)**	**Interoperability Systems Analysis**
	(10)	**Demonstration of Grid-DP Interoperability**

Program Team

- Gas Technology Institute - GTI
  - Michele Dybel, Project Manager
  - Karen DePodesta, Technical Lead
- Encorp
  - Randy West, Program Manager
  - Larry Adams, Chief Engineer

GTI's Distributed Energy Center

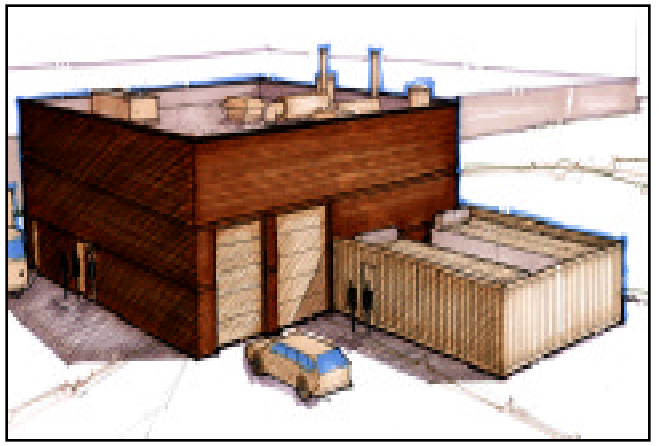
Focused on development and deployment of DE Technologies:

- CHP for Buildings Packaged Systems
  - Waukesha-Trane, Capstone-Broad,Takuma
  - Cummins-Munters, UTC Fuel Cell w/ Flywheel
- Distributed Energy Technology Center
- National and Regional Consortium Efforts
  - Regional BCHP Application Center
    Teamed with UIC's ERC (www.chpcentermw.org)
  - MW CHP Initiative
  - Mutual Funds: DG, Gas Cooling, National Accounts
  - DE Collaborative (RAP Process)
  - Emissions Initiative
- Energy and Environmental Planning
  - Energizing America's Cities

GTI's Distributed Energy Test Center

Test Cells up to 3000 kW

- DG Equipment
- Heat Recovery Equipment
- Grid Interconnect or Island Mode



- Turbines and Microturbines
- Reciprocating engines
- Fuel Cells
- Packaged units with absorption chillers
- Packaged unit with direct-drive chillers

Who Is Encorp?

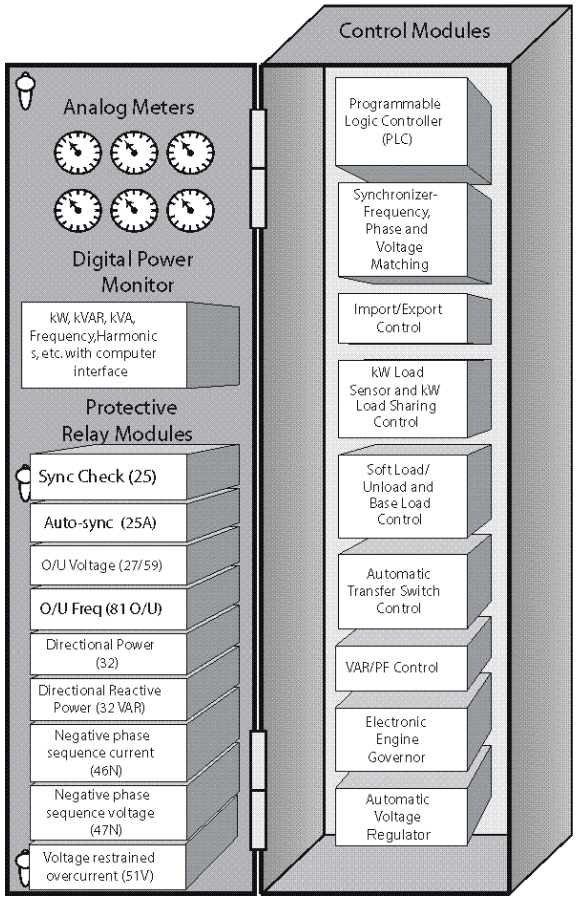
- Fast-growing, technology-driven company located in Windsor, CO
- Encorp develops and markets software and hardware technology solutions for the communication, control, and networking of distributed energy.
- Extensive market experience:
  - Over 1700 different applications
  - Over 1,000 MW installed capacity

Core Enabling Technology
GPC Enhancements

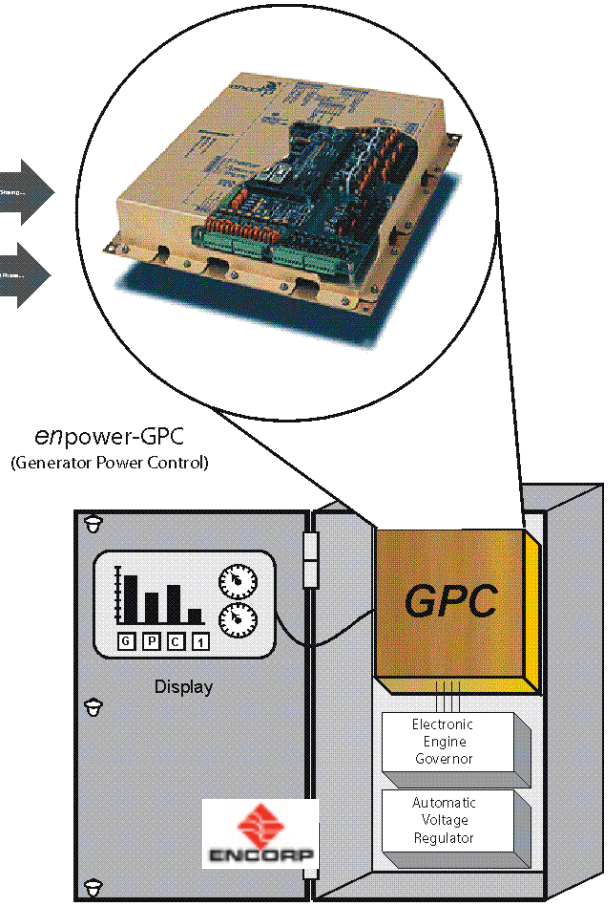
- Performance
- Communications
- Scalability
- IEEE P1547 Compliant
- Functionality
- Programmability
- Serviceability
- Lower System Cost

Encorp's Differentiator:
The Gold Box & Remote Energy Automation

Traditional Method



Encorp's Digital Solution



Encorp End to End Energy Solutions

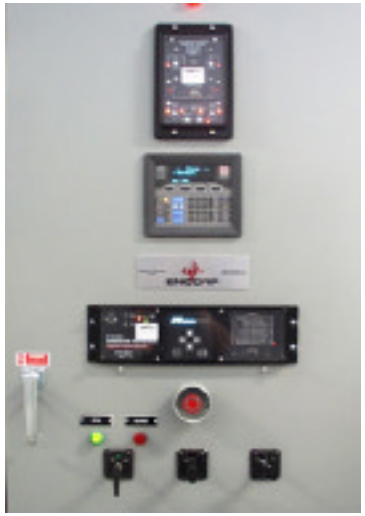
entelligent
Virtual Power Plant
Software & Comm.

MMC & GPC Controls

Digital Switchgear 100 – 600 Amps

Digital Switchgear 800 – 5000 Amps

Inside Panel

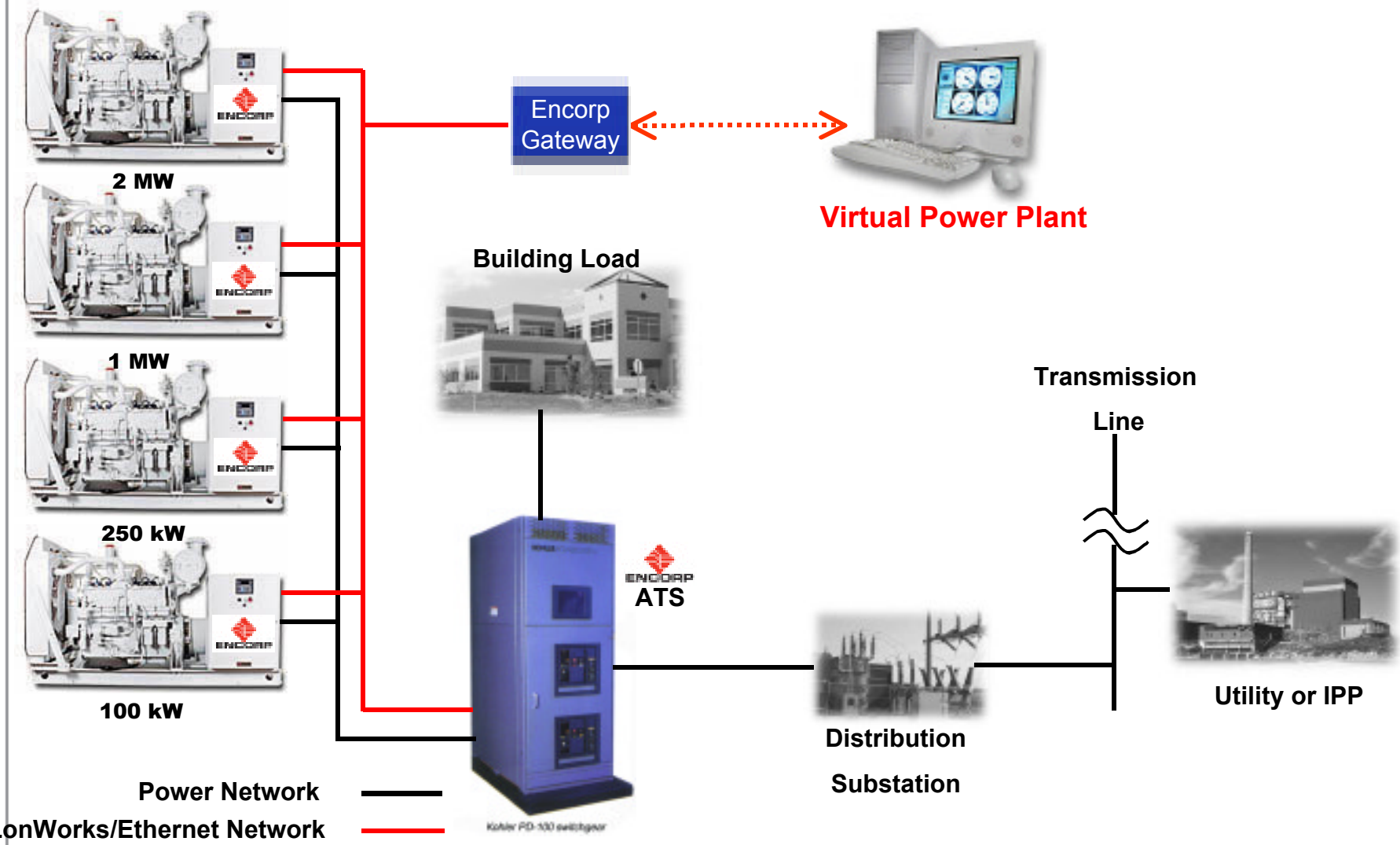


Outside Panel

Digital Control

- Engine Start/Stop Sequencing
- Engine Sensor Monitoring
- Generator Control Functions
- Utility and Generator Protective relays
- Power Metering (Energy)
- Power Quality Monitoring (Harmonics)
- PLC Logic and networked I/O expandability
- Network & telecom communications
- Local & remote PC communications interface

Encorp's End-to-End Energy Solutions



Base Year Accomplishments

- Core Technology Development
- Functional Product Specifications Outlined for Advanced Controller
  - More powerful processor and enhanced controller architecture
- New Controller Provides Several Advances
  - Up to twenty fold improvement in processing speed
  - Reduced manufacturing costs
  - Simplified strategy for wiring and terminal connections
    - Reduced manufacturing and field installation costs
  - Expanded set of controller functions & scalability
  - Expanded communications capability

Base Year Accomplishments

- Developed anti-islanding control scheme
- Developed loss-of-synchronization control scheme
- Results from field application of GPC controller
  - Communications requirements
  - Communications topology
  - Communication protocols
  - Monitoring points
  - Load management
- Draft annual report
  - Final report by July 31, 2002

Option Year 1:
Application and System Level Command and Control

- Task 6: Type Testing of Advanced controller
  - A: Test plan
  - B: Perform Testing and prepare a report
- Task 7: Develop System Command and Control System
  - A: Functional Specification for Command and Control System
  - B: Incorporate these functions into controller
  - C: Develop extended dispatch capabilities
- Task 8: Demonstration of Controlled DP Resources
  - A: Demonstration Plan
  - B: Demonstrations implements several DPs
  - C: Demonstration report with recommendations

Option Year 1: Project Issues

- Option Year 1 under negotiation
- Delays in IEEE P1547 standards development
  - Impacts controller requirements
  - Impacts controller testing (Option Year 1, Task 6)
- Market changes
  - Impact controller requirements/implementation
- Technology changes
  - Impacts design implementation of Base Year controller

Schedule under Development

2002 Accomplishments

- Modifying Base Year controller due to:
  - Market feedback on new controller
  - Changes in overall DG market
  - P1547 standards development activities
  - Technology changes since inception
  - Base Year demonstration experience and knowledge

2002 Accomplishments

- Controller Changes
  - Implementing a phased development approach
  - Eliminating features that were not cost effective
  - Leveraging Analog board of current Goldbox
  - Added 2 additional RS232/485 serial I/O channels
  - Creating a standalone PSM capability
  - Technology Review
    - New DSP chip for PSM
      - Moves more functionality into PSM (not split control)
      - Added modbus display capability to PSM

2002 Accomplishments

- IEEE P1547 Developments
  - Target for release as a standard this year
  - Proposed Standard clarifies key issues that impacted design.
  - Clarifies required testing
  - Encorp is an active participant in all of the IEEE P1547 standards development activities.
    - P1547 Interconnection Standard
    - P1608 Application Guide to P1547
    - P1589 Test Standard to P1547
    - P1614 Monitor/Control/Information Exchange Guide

Summary

- Significant Opportunity Exists For Further Improving Distributed Power Value Proposition
- Advanced Interconnection Controls and Switchgear a Critical Part of the Equation
- Developing Consensus IEEE Standards for Interconnection and Communications Vital
- This Collaborative Program Has Resulted In Significant Technical Advances
  - Improved controller performance, greater functionality, and reduced switchgear cost
  - Our thanks to DOE, the Office of Power Technologies, and NREL for their support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